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Abstract

Science education is crucial for shaping the culture of science and its practitioners. Boundaries currently limit ties between natural and social science education structures, exposing the public to a one-dimensional science and its possible ramifications. Believing this to be a "crisis," I explore a variety of approaches to re-visioning science education and the ensuing forms of resistance that these face. In addition, a more personal accounting of my experience with trying to integrate social and cultural issues into the education of scientists allows me to explore the forms of resistance I faced; bridge the gap between theory and practice; and locate more effective ways of re-visioning science education.

Key Words: science education, interdisciplinarity, resistance

Introduction:

In *The Structures of Scientific Revolution* (1962, 1970), Thomas Kuhn set the stage for many social studies and feminist analyses of science (Keller 1998) which question not only the practice of science but also the acculturation of both basic and applied scientists. His classic exploration of the growth of science demonstrated how science should progress and change as new findings and discoveries are made in any field of science that affects one's own subdiscipline. This might be considered analogous to adaptations within and between populations, considered community interactions, which allow them to survive rather than perish. At present, the scientific community does not appear to be "self-correcting" as Kuhn claimed a community in crisis would be. While much of the science community does not see a crisis, feminists, among others, have; and, they have actively examined the nature and culture of science in an effort to resolve this crisis. Critics of science argue that the "objective" and "value-free" structure that science claims, and which Kuhn acknowledges must be present, is far from objective and value-free. Moreover, many feminist scholars proclaim that normalized masculine rationality and exclusionary practices within science serve to reinforce the hidden dimensions of science communities that lack objectivity and value-neutrality (Harding 1991; Keller 1985).

Parallel to these epistemological critiques are questions about the nature of science education. Whom do we teach? What do we teach? How do we teach? Recently, science professionals—19 men, 1 woman—focused on how to prepare graduate students for specific employment opportunities outside of academia, but masked the importance of these very fundamental questions (Committee on Science, Engineering and Public Policy 1995—CSEPP). Similarly, many students never consider that the process of conducting research (What do we study? How do we study it?) is a uniquely human experience that can have very clear political motives.

In contrast to the CSEPP, the National Research Council (NRC) and the National Science Foundation (NSF) have questioned science education. In particular, they have called for broader training and a greater balance between research and teaching for scientists in an effort to "democratize" science (Barr & Birke 1998; Bloom 1997; Petersen 1996). According to Barr and

Birke (1998), such a democratization of science means awakening the scientific community to its own context-bound assumptions and values (e.g., white, heterosexual, masculine, capitalist), hoping to challenge and expand what is accepted and taught as "science."

Science education is crucial to shaping, and possibly reconfiguring, the culture of science and its practitioners. Currently, science education is centered on the learning of facts, theories and procedures that are "…separated from conceptual understandings and decontextualized from their social, historical, cultural and political contexts." (Barton, 1998:13). Moreover, scientific knowledge is developed, and taught, within a positivist tradition where conventional relationships between teacher and student, and between scientist and non-scientist, are built using hierarchical power structures. Students also experience science as a culture, i.e. norms, beliefs, and methods of reasoning and communicating, although they may not recognize the acculturation as fundamentally different from that of other disciplines.

Feminist studies of science education have provided a site for examining the pedagogical features of science education. Some studies focus on developing innovative classroom techniques such as collaborative and participatory learning (Mayberry & Rees 1999). Ultimately, these techniques should provide instructors and students with an appreciation for situated knowledge and learning that values personal experience, encouragement of social understanding and activism, and development of critical thinking and open-mindedness. Although these concepts are familiar in women's studies, science educators are less likely "…to acknowledge [their] potential to transform the traditional conceptualizations of scientific thought that fail to acknowledge the role of culture in the production, dissemination, and utilization of scientific knowledge."(Mayberry & Rees 1997). Incorporating cultural and historical context into natural science curricula, preferably into the core courses, would clearly alter the education of natural scientists.

Thus, there is a need to re-vision the boundaries that currently preclude ties between natural and social science education, where constructivist practices are more widely accepted. Re-visioning involves creating interfaces that are more fluid, questioning the practices that maintain the boundaries, and allowing individuals to engage in interdisciplinary work that is valued rather than marginalized. However, such re-visioning often faces strong resistance from within the scientific and, indeed, the academic community. The resistance is partly a response to change and to the unknown, since most scientists are specialists in their (sub)disciplines whose authority is difficult to question. Interdisciplinary programs (e.g. environmental studies) are seen as "less rigorous" rather than more challenging and are typically undermined by scientists. Finally, there is also resistance to considering science as exclusionary because scientists argue that it is objective and that identity plays no role.

In this paper, I explore the boundaries between natural and social science education by analyzing both the forms and processes of resistance I have observed from within my institution. This manuscript is a theoretical argument, complemented by personal experience from two different disciplines (biology and women's studies), that lends insight that might help to change science education.

This work begins with a brief statement about what science students and professionals have had to say about science education. Within this section I address the notion of scientific method as objective and truth-producing. Next, I focus on resistance to change in science education and examine the ways in which the status quo has been maintained. Finally, I present my experience with crossing disciplines and, in keeping with a feminist perspective, include these experiences as data to support the theoretical statements.

Breaking Down Myths of Scientific Objectivity and Truth

> Science content must be embedded in a variety of curriculum patterns that are developmentally appropriate, interesting, and relevant to students' lives (National Research Council, National Science Education Standards, 1996: 212).

The training and education of natural and applied scientists, doctors and engineers, has come under intense scrutiny in recent years. One concern is that pre-college teachers are not training students in science courses to think, but rather to accept the authority of a text. Another concern is the high attrition rates of science majors. Fueled by negative experiences in freshman college science courses, 54% of science and engineering majors surveyed said they chose to pursue another field of study (Seymour & Hewitt 1994). In particular, they noted that negative pedagogical and peer group experiences were important influences in their decision to switch to another major. One Hispanic male "switcher" summed up his thoughts this way:

> There's no room for discussion or theory. You just take notes and this is the way something is. There are no different viewpoints.... I found the lack of any kind of human quality very boring (Seymour & Hewitt 1994: 250).

Students in Seymour and Hewitt's confidential survey have not been the only students to express their frustrations. Biology students at the University of California at San Francisco have verbalized their angst over their education, which they have called "one-dimensional" (Bloom 1997: 907). While some students are aware of problems with their science education, many are not. For every student who complains about and/or leaves the sciences, many remain and become indoctrinated into a science culture that is largely operated under a (mis)guided sense of cultural objectivity and absolute fact. This indoctrination produces among its members a sense of superiority and elitism based on the general perception that objective fact-finding and knowledge production reveals truth (often with a capital T). Belief in this "Truth," tends to rule out alternatives and often alternatives cannot even be envisioned.

In the case of science education, "Truth" production can omit or marginalize issues and individuals who may not fit within the norms of what should be included in a science course and how this information should be presented. Omission or marginalization results in issues and people being left unaccounted for within science. Additionally, specialists are taught to remember facts, but often not educated on how their actions affect other organisms, including people. In what may seem to be an extreme example, natural scientists and physicians often create information about groups of people in the absence of social awareness and, historically, this has fueled social problems related to race, class and gender. As a case in point, Cuvier, Darwin, and Lyell, all leading natural scientists of the nineteenth century, were instrumental in shaping the ways that human "norms" were established. Normalizing and upholding some characteristics as superior (e.g., whiteness, masculinity) made it possible to place certain groups of people in other, subordinate categories based on culturally constructed identities of race, class and gender. However, the constructions were promoted and accepted as scientific fact because of who the founders were and not necessarily because of the accuracy (or adequacy) of the constructs.

If social problems and inadequate health care result from a one-dimensional structure of science education, and the NSF and NRC have called for change, how has the issue been addressed within higher education? In the academy, where we pride ourselves in being open-minded, we may only be reinforcing the problem. Academic institutions, by and large, perpetuate cultural myths. Institutionally, we assign authority in a hierarchical manner where moving up the ranks of authority necessitates our passing through a variety of tunnels that are—structurally, categorically and culturally—easier for some than for others. Additionally, we uphold a strict patriarchal model when we teach in classrooms with seats bolted in place and students facing "the podium of knowledge." This type of classroom makes pedagogical change such as student-centered discussions, instead of lectures that are mostly authoritative, very difficult if not nearly impossible.

Moreover, a hierarchical ordering of disciplines is maintained, with the "real" and "hard" sciences at the top and all else falling short to one degree or another. Evidence for this can be viewed on nearly any college or university campus, most noticeably in the greater space, budgets, salaries, and overall resources allocated to the natural sciences than to other disciplines. Furthermore, most "outstanding" universities are judged so because of their scholarship, which is measured by the number and dollar amounts of research grants held and most grants and dollar amounts secured come through the natural sciences. Additionally, most of these grants come from outside the academy, suggesting how strongly the public and private sectors support science. Grants are available for faculty in the non-natural sciences, but these grants are generally fewer in number with values significantly lower than what natural scientists receive. These very real economic disparities serve to accommodate the "...cultural authority of scientific knowledge and the political autonomy of science" (Lafollette 1998: 7). The perceived superiority of science is also evident from the perspective of students, many of who resist taking natural science courses (because they are too hard) or assume that social science classes are easy because social science is just opinion and a bunch of ideas.

The structure of the academy also encourages science faculty to view students as coming from particular age, race, and class backgrounds. Many have likely generated lecture and classroom materials based on the presumed white, middle-class, and male student body and, when confronted with difference in the classroom, continue to teach in the same way despite evidence that learning is more meaningful in constructivist, rather than positivist, environments (Mintzes et al. 1998). When the classroom diversifies and we have not adapted our teaching materials to relate to this diversification, those students who are "different" from the mainstream will likely suffer academically. Thus, we help perpetuate the hegemonic, scientific order of the academy.

Challenging Science Education: Envisioning Change

Many of the "norms" of the academy have been, and continue to be, challenged and changed for a host of reasons and in a variety of ways. Traditional meanings affiliated with academia, including a hierarchically rigid ladder of authority, have been contested as a result of a more diverse faculty (US Department of Education 2003). For example, the identity of "the professor" is shifting from those features associated with traditional white, male norms as more women and people of color receive doctoral degrees and join faculties. Additionally, more "non-traditional" students are seeking degrees, transforming campuses and classrooms into spaces that contain a wide variety of cultures, experiences, beliefs and practices that exist across the globe. This diversification, among faculty and student populations, will continue as so-called “minorities” begin to claim a numerical majority of the U.S. population. Finally, new technology has led to physical changes within academia. Classes are more like commodities as students can register for courses offered on one campus but attend the class from another, courtesy of a live video feed. Other changes that have, in part, resulted from advances in technology include WEB-based courses and courses on tape or video, which are multiplying at an amazing rate.

Many faculty and administrators support and encourage such changes as simply a response to the “natural” processes of diversification. However, the culture of science, including the education of scientists, has not always embraced diversity. Some feminists envision a less hierarchical, patriarchal and exclusionary model for science and science education, yet they do not always agree on the “cure” (Barton 1998; Haraway 1997; Harding 1991; Longino 1996; Rosser 1997; Shepherd 1993). For example, Shepherd (1993) proposes that science would become less biased if we appreciated female <u>and</u> male ways of describing and knowing the natural and social worlds around us. In turn, she believes that this would encourage more women and people of color to enter the sciences. Others have maintained that the model of modern science itself is problematic and that simply changing the composition of the scientists is not enough (Harding 1998; Keller 1985; Longino 1996). These scholars argue that we must address the social and cultural issues that exclude groups of people from these disciplines, thus, going beyond Shepherd’s dichotomous model of how women and men think differently. Without such an investigation, they claim that change in the institution of science or the academy will never occur.

Although these are primarily theoretical answers, other feminist scholars have taken an applied stand to integrating social and cultural issues in science classes (Mayberry & Rees 1999; Rosser 1995).

Alternatively, we can attempt to draw natural scientists to the courses where they will be encouraged to think about social and cultural issues in relation to science. Entire programs, such as Science and Technology Studies (STS) have been created and are designed to promote and formalize interdisciplinarity. Although these programs provide some students insight into the social and cultural construction of science, it is unlikely that all science majors are required to take courses offered through these programs. Therefore, while a subset of students who are focused on receiving a Bachelor of Science degree will attain some awareness of the relationships between science and culture, the majority of scientists will remain in their disciplines of physics, biology and chemistry. In practice, however, this structuring marginalizes STS by placing them outside of the core science requirements. This further undermines the message and intent of interdisciplinarity.

Above and beyond the difficulty of capturing science students in STS courses, I question the degree to which interdisciplinarity truly exists within STS and similar programs. The courses that make up the curriculum in many of these programs come from a variety of disciplines so perhaps they are, in reality, multidisciplinary. In order to be more interdisciplinary, one faculty might attempt to teach the same topic from multiple perspectives rather than from a single perspective. Such an approach can be risky. It requires leaving the comforts of our well-educated disciplinary perspectives to engage in new ways of thinking about and critiquing issues, including our own disciplines.

I have personal experience with this approach, hoping that my class entitled Women and Science (see below), will engage both natural science and social science students. It is offered as an “exit” course within the General Education requirements, so that students outside of Women’s Studies (home to the instructor and course) can receive credit toward their degree, even if not toward their specific major. Exit courses are at a premium at my campus, so the course is appealing to students from a variety of majors although science majors tend to want a course on women in science - the distinction is important and will be addressed in the section about the course. Although students report that the class changes their perception of science, this approach has limited potential to affect science majors because the course is offered only once a year and is capped at 35-40 students.

Classes and programs can be sites for interdisciplinary approaches but collaborative research can also cross disciplines. Unfortunately, more often than not it is multidisciplinary and accomplished by faculty functioning within their own disciplines and bringing a piece to the whole project without necessarily knowing how their piece fits -- other than in an additive sense. However, just like living systems, such as human bodies, simply adding together the basic parts (i.e., cells) without integration produces nothing functional. That only is achieved by work that is collaborative and relational, by blending together several different perspectives (feminist, scientific and pedagogical), requiring an interdisciplinary analysis of the ways in which culture can be brought to the natural sciences.

While there is support for interdisciplinary work that brings disciplines together, there is also a powerful force of resistance that comes from multiple locations. Like many, I advocate for an interdisciplinary, inclusive and challenging atmosphere in academia. However, the reality of promoting such an atmosphere suggests that many oppose these changes, which leads to a few basic questions. First, why is it that universities are places where such enormous resistance to change occurs? Second, where does the resistance come from; what enables it? Third, how can we promote such change, more effectively, in ways that will be obvious to students, faculty and administrators? In order to address these questions, I consider the avenues through which resistance occurs.

Resisting Change: Maintaining the Status Quo

The Academy includes a group of sub-disciplines, in both the natural and social sciences, which have traditionally been dominated by (white, heterosexual) men and by a patriarchal model for research and knowledge production. The scientific method, as it is called, produces "objective" knowledge with its systematic collection and analysis of data. This "objective" style of research confers a great deal of legitimacy, respect and power to those who employ it (e.g., practitioners of science). Indeed, the presumed objectivity of the scientific method can empower scientists and practitioners with grand support from the general population, such that any perceived threats of change are easily discarded. It has been demonstrated, however, that science does not necessitate objectivity, as the following shows.

Leading 19th century physician and craniologist Samuel Morton hypothesized that the skulls of white males were larger than the skulls of women and people of color. He then proposed, with no scientific justification, that the larger the skull the higher the intelligence. Thus, positive findings would demonstrate that whites were more intelligent than non-white. To "test" his hypothesis, which he ultimately confirmed, he "scientifically" and "systematically" measured the volumes of skulls from numerous races. Several years later, a scholar was studying Morton's work and discovered some problems with the raw data— all of which was published. While Morton's work was believed to be scientific, and therefore unbiased, he had actually misrepresented many races within the study. His Native American sample contained a disproportionately high number of smaller skulls while the Iroquois, who had larger skulls, were grossly under-represented. Furthermore, he included only three Hindu skulls in the sample of white skulls. Many more were available to him but all of the Hindu skulls were extremely small and would have lowered the overall score for the population of white skulls (Gould 1981). In other words, in order to prove his hypothesis, he manipulated the study and the data, a clear use of his subjective will.

Despite the revelation of similarly biased studies (Fausto-Sterling 1995; Tavris 1992), many have actively fought to maintain the current scientific model. Whether conscious or not, many of these resistors engage in a process of "Othering" (Fine 1993; hooks 1990). This process leads those in dominant positions to speak of Others as somehow deficient or fatally flawed. Figuratively and literally, the Others are pushed to the margins and homogenized in ways that allow differences within the marginalized group to be disregarded. At times, this speech even "annihilates, [or] erases" while creating and defining the Other in ways that reinforce and substantiate those in positions of dominance (Hall 1991; hooks 1990: 151). Regardless of the precise configuration it assumes, Othering preserves a system of domination and submission by marking the Other as separate from and inferior to those deemed "normal."

An example of Othering within science communities involves the preservation of a hierarchical ranking or model of its practitioners. For example, women who choose to become scientists are often viewed with suspicion and are often constructed as Others who are "naturally" different from men. This difference, some would say, makes women less capable in the science world. Women are often perceived to be "less serious" scholars than men because they have a womb, which can be defined as a "natural," female distraction that might/will pull them away from their "real," science work.

Also, women have been perceived to be less knowledgeable, rendering them open to more challenges (than men) by both women and men students (Kierstead, D'Agostino & Dill 1988). Additionally, women's research has been evaluated with more cynicism than articles by men have been. In fact, fewer papers are accepted for publication, and fewer and smaller grants are awarded to women researchers. Ironically, science articles published by women have a greater citation rate -- 24.4 per paper versus 14.4 for the men (Holden 1996).

Finally, women who choose to question and examine the scientific culture are Othered in a myriad of ways. For example, women who choose to teach science by adding "social" elements to the topic, and who are willing to talk about it, are criticized for including material that is "not related to science." Thus, these women are highlighted and defined as inferior scientists, and often hear about it when it comes time to be evaluated another. Rather than being commended for exploring the all-too-real connection between science and society, these scientists are marginalized (Fausto-Sterling 1997). Often, women who critique tradition science leave their discipline of choice and join other groups. While these alternative homes may be more open to new ways of doing science, traditional science communities also marginalize them. In turn, this reduces the scientists within these communities to an inferior status.

In these claims, and countless others like them, women are evaluated based on "biological destiny," and on their "naturally inferior mental abilities." In the face of such adversity and its cumulative impact on women (Schiebinger 1999; Wilson 1995) some have argued that we are asking the wrong question. Rather than asking why there are so few women in the natural sciences in specific, and academia in general, we should be asking how there can be any at all. As indicated earlier, many people who recognize the problems with science often leave, suggesting that science is less examined/critiqued and further isolated. And the question remains unanswered; how can the rigid boundaries between the social and natural sciences be re-visioned?

In order to address this question, I turn to my own experiences with attempting to blur the boundaries of academic disciplines. Each experience reveals a host of different settings and players who resist this blurring in multiple ways. By presenting these experiences, we move beyond the purely theoretical critiques of science, though I use this theory as a foundation for our analysis.

There are two goals in sharing and analyzing these experiences. First, the very recounting of them brings this "problem" into a more vocal and visible light -- for non-scientists and scientists. Like others, I recognize why it is important that we are part of our research and why our stories need to be heard (Mayberry, Subramaniam & Weasel 2001). Hopefully, these stories will compel others to share their stories as well. Second, a systemic analysis of these experiences will yield more complete knowledge of situations that facilitate ways that knowing are "regarded" within science communities. For example, what forms of resistance were encountered? Who and what supports and/or performs resistance to this effort? How do we respond to acts of resistance, and can we learn from our reactions if better responses might yield better results?

~~Women In~~ Women and Science

What does it mean to be "outside the discipline"? It may not always be clear, but once an individual even thinks of venturing outside the lines, they hear sounds of alarm. Earning and maintaining insider status is vital to a scientist's progress, so the alarms suggest. Even undergraduate science majors learn this lesson quickly.

I was no stranger to this lesson. As an undergraduate studying biology, it was clear that I had to take as many biology, or other science, courses as possible and should not waste time with other subjects. However, in addition to my major, I also minored in Environmental Studies where I was required to complete one social science class. I chose cultural anthropology and can remember, very vividly, my beliefs about that course; it was a course I could and did skip. It was not a course, I reasoned with the assistance of internalized scientific culture, like my biology courses. We discussed topics and did more reading in the anthropology class. On the contrary, I felt that if I missed a biology course, I would have missed "critical information," since professors told us what we should know and read. I never questioned this belief or practice and it is one that persists among biology students today.

Despite my own entry into the scientific culture, I now find it difficult to teach science students with the ethos I had as an undergraduate. As a faculty member in Women's Studies and environmental studies, I am visibly outside the bounds of real science. So when I do teach young scientists, they often come to class with the same mentality I had for that anthropology course. In a course in which I repeatedly draw connections between biology, technology and society, science majors' (generally 80-90% of my students) comments on course evaluations clearly demonstrate their beliefs. One particularly poignant comment provided anonymously by a student reads:

> (She) keeps repeating that we should be more concerned with learning than with our grades-yeah, right--this is a social science class--contrary to popular belief, this class is not important. We took this class to get a good grade--we can learn when we're taking real classes, chemistry, biology, mathematics, not this stuff.

Without a doubt, this undergraduate, and others like her/him, had already been cleanly and crisply indoctrinated into the culture of science. The faculty within this department, and the department itself, fostered this sort of mentality, as one recent experience clearly demonstrates.

Several years ago, I taught a course entitled Women and Science at the request of the biology department. The registered science students reported that they believed they were going to learn about famous women in science, rather than women and science, and that had compelled them to take the course. This came as little surprise since the biology department had advertised the course with flyers proclaiming a new course that would teach them about the famous women in science. By advertising it as women in science, they were telling students that there is no discrepancy, bias or discrimination within the natural sciences; only important players, some of whom were women. Other departments, such as chemistry, offer courses that focus on the participants in chemistry using a historical perspective (although students report that no women are included).

My first class, offered through biology, was composed almost entirely of women who were majoring in biology and even today it is primarily women who enroll in the class. The current situation is not surprising since the course is now offered through the department of Women's Studies where men tend not to venture. In effect, by keeping the course in Women's Studies rather than integrating it into the undergraduate science curriculum, the departments of natural science support the course only as an illegitimate one.

When the course was offered as a biology course, one male faculty member inquired "why do we need a course about women in science?" Experience suggests that if one individual asked the question, others were surely thinking it. This type of resistance to inclusion of "other" materials (e.g., women in science courses; sexuality, culture, race/ethnicity in medical training) is common, and yet seldom occurs in the reverse manner. For example, faculty members do not contest the fact that animal behavior is taught in biology rather than psychology. Science has claimed a domain and departments help preserve this domain as untouchable.

Undergraduate science majors emulate the department's divide and conquer mission. Students express, in their own ways, resistance to courses not "scientific" enough for them. While they may not have verbalized possible hesitations, let alone resistance, to learn about biases or inequities in science and technology, they were capable of expressing that their interest was only in learning about those famous women who made it in science (emphasis added). On the first day of the course, I always ask students to write down what they hope to learn in the class. Almost all want to learn about women scientists.

Discussion

Systemically, requirements for natural science programs are almost completely structured, and often consume nearly all of a student's educational time. Whether a student is consumed by her/his chemistry requirements—courses, labs, etc.—or by rigidly prescribed courses and clinical work in medical school, the results are the same. This structuring leaves little, if any time for material outside the discipline. Moreover, supremacy and overall virtue of their own discipline becomes clear when most/all of a student's study is housed within the discipline; courses outside are not required, and sometimes not encouraged, thus they are unimportant. Content from non-science courses is seldom, if ever, incorporated into the discipline's testing regime.

Natural science education programs promote a goal-oriented focus, which ultimately separates science disciplines from others that might use another model (e.g., inquiry based). A goal-oriented focus has students concentrate on individual goals as being central to long-term goals. So, if a student wants to be a scientist, s/he identifies the individual goals that must be accomplished. While I appreciate the importance of goal-orientation, such a focus has limitations with serious consequences for the populace. Clearly, the most important limitation involves a learned culture that fails to incorporate a social and human aspect of the world within the world of science and of scientists. Additionally, this structure virtually excludes non-science students from taking a science course. An "us-versus-them" mentality ultimately results.

It is clear that structures contribute to separating and ranking of disciplines. Interpersonal actions, such as socialization, also factor into this schism. For example, the faculty plays a key role in socializing our future scientists, engineers and doctors, often teaching the students how to exclude those "deemed" inappropriate. Whether or not the resulting separation of disciplines is a conscious goal is not the issue. The fact that this is the outcome is what seems important. Furthermore, by structuring major requirements that exclude the courses taught outside the natural sciences, departments and their members relegated non-science work as unacceptable. Structuring acceptable courses for majors takes place in all disciplines and is not limited to the natural sciences. In effect, the procedure not only defines a field by revealing what is and is not part of the discipline, but also excludes and marginalizes "others" by outlining how they differ from what is accepted. Evidently, the process of normalizing separation is relational, and involves interaction between individuals and institutions. This process simply validates and strengthens a system that literally separates disciplines and secures boundaries that keep them apart. Thus, goal-orientation is empowered, as is the "understanding" of what is important. Again, the problems arise out of and are maintained by both systemic and interpersonal arenas, and through their interactions with one another.

Given my, and others, attempts at bringing social and cultural issues to the sciences leaves me with serious concerns about the intense socialization of students into a science-only ethos. Science students are led to internalize a rigid culture where science is omnipotent. By the time we encounter them in a social science elective or exit course, we are seen and treated as the "other." In fact, if they take our classes and run into intense reading and writing loads, students make it all too clear that they do not have the time for this, especially in a non-science course. Even at the post-graduate level, for example where students are in medical training, learning about people who they will likely face in a physician's office strikes many doctors-in-training as unimportant; especially when they learn from peers that this material is not covered on their annual examination.

If problems occur at both the structural and interpersonal levels, then we must look for resolutions at both levels. For example, one of the best methods of re-visioning the disciplines involves incorporation of difference within our courses; and not by means of bringing in an "other" for the occasional, special guest lecture. Instead why not re-vision an educational system where breadth of knowledge, on the part of both the instructor and the student, is valued? This is not to suggest that specialization is no longer necessary. However, the professor of a given science course ought to be able and willing to present basic social and cultural issues, just as a social science professor ought to be able to give fundamental chemical or biological perspectives if relevant. Unfortunately, most are probably reluctant to engage in this type of cross-disciplinary teaching, especially if they feel ill equipped to do so, or if they receive little recognition or credit for doing this. Additionally, there is really no incentive, currently, for faculty to learn the material -- we are already successful in a system that rewards specialization and not breadth of knowledge. Some incentive at the structural level must be established in order to encourage faculty to seek further training. Neither structural incentives nor one faculty changing a course can create change on its own.

This analysis and the suggestions for change are predicated on the idea that science education focuses on "the development of the ability to think" (Bybee 1993:86). What seems dissonant is the current notion that science students can be trained to think (or recall) an/the answer without integrating social and scientific contexts.

Additionally, this evaluation rests with Thomas Kuhn's (1962/70) belief that "mature science" withstands "scientific revolutions" by transforming paradigms. Kuhn argued that most, if not all, revolutions occur as a result of some crisis. In his context as well as mine, crisis refers to progress, contestation, inventions, or even proof that an old paradigm is no longer sufficient. These crises may be generated within a scientific community that ultimately goes through revolutionary changes. Or, a discovery in chemistry, and maybe even political science, might generate a crisis in a third department where economics or globalization are taught. Regardless of the origins, a crisis "suppl[ies].... a self-correcting mechanism which ensures that the rigidity of normal science will not forever go unchallenged" (Kuhn 1970: 181).

Today academics work within fairly isolated arenas, and perhaps we do so out of a fear of challenge. Fundamentally, this isolation is our modern crisis, and it is time for change, especially in science education where both thought models, inquiry based and goal orientation, must be integrated. Incorporating an inquiry-based model with the goal-orientation model would train more science and medical students to consider how their trade impacts, both positively and negatively, the world around them. An incorporated model will produce new perspectives and methods that lead to changes in models, experimental subjects and interpretation of data.

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